Distinctive Weather Patterns During the 1957 Shurin

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John C. KIMURA*

Abstract

The summer sea-level isobaric pattern in eastern Asia is characterized as being uniform, with weak fronts separating the continental from the Pacific air. Most of the storm systems that influenced Japan during the 1957 Shurin were related to depressions that developed in Siberia or wave cyclones that originated on the Polar Front in the East China Sea. At the 500 Millibar level, the Subtropical Westerlies became evident by the end of the second decade of August, and confluence between the Polar and the Subtropical jet streams occurred soon thereafter in northern Japan. In early September, an outbreak of the Polar trough settled over eastern Siberia, and the Subtropical jet stream migrated southward. On August 31, the jet stream was located over Akita; by September 15, over Tokyo; by September 20, over Hachijojima; and by October 9, it was observed near Torishima.

There were four distinct weather patterns during the Shurin of 1957. Three were associated with precipitation and one with fair weather. The precipitation types were: typhoons and their downgraded depressions, stationary fronts, and extra-tropical cyclonic depressions.

Acknowledgements

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1. Introduction

From late August to the middle of October, the Shurin season dominantes the weather picture in Japan. The autumn rainfall maximum is caused by the southward migration of the Polar Front over the Japanese Islands. This condition prevails until the Siberian High begins to dominante the weather in October.

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This is the second in a series of reports concerning the Japanese Shurin, and will be primarily devoted to weather characteristics during distinctive patterns at selected stations as interpreted by hourly meteorological data[1], daily sea-level charts[2], and 500 Millibar charts[3] for the 1957 season. Subsequent investigations will be concerned with characteristics of the meteorological elements during the Shurin of 1957, and a regional analysis of the Shurin as interpreted by average daily values.

The beginning and the end of the season[4] were determined by an analysis of average daily values[5]. Average climatological characteristics for the season were readily discernible. Daily meteorological data published in the Monthly Report of Japan Metelrological Agency[6] for August, September and October, 1957 through 1961, for eighteen stations[7] throughout Japan were graphed and compared with those previously constructed with the average daily values. Graphs illustrating precipitation, cloud cover, maximum and minimum temperatures, temperature range and atmospheric pressure were compared. Although the daily values for 1957 may have differed substantially from the average daily figures, the 1957 patterns most closely resembled those of the average daily values. This was especially noteworthy for precipitation and cloud cover. Accordingly, it was assumed that for the five-year period, 1957 through 1961, the 1957 season was the most representative.

This report consists of a description of daily sea-level and 500 Millibar synoptic charts and an analysis and correlation between hourly meteorological data of seven elements with sea-level and 500 Millibar charts for periods during particular weather patterns that were characteristic during the 1957 season. Hourly data were graphed and charted for eight weather reporting stations[8] throughout the country.

2. Analysis of Daily Synoptic Weather charts

Daily sea-level and 500 Millibar weather maps from August through October, 1957, were analysed to determine meteorological characteristics at these altitudes. Descriptions for both of these levels follow:

1. *Sea-Level Charts*

The daily sea-level charts for the first decade of the month of August show that the isobaric pattern over East Asia was relatively uniform. The Ogasawara High was in complete dominance, with only weak fronts separating the Pacific from the continental air masses. These fronts did not cause an appreciable amount of precipitation and slowly migrated to the southeast. During this period, weak migrating high pressure cells from the continent were well to the north of Japan.

During the second decade, though the fronts were still relatively weak, the depressions deepened and progressed toward the Kamchatka Peninsula. These centers of low pressure had two distinct soruces of origin: Siberia, and on the Polar Front in the Mid-Yangtze Region. The derpressions that influenced the islands of Japan during this period were those that developed in the Mid-Yangtze. Wave cyclones deepened and progressed northeastward adjacent to Japan. The depressions that formed in Siberia did not affect Japan during the pre-Shurin, but increased in importance as the season began. They traveled eastward twoard the Kamchatka Peninsula before the Shurin, but at the onset they swung to the south.

During the second half of the month, Typhoon No. 10 (Agnes) took a north-northwesterly trajectory from southern waters, passing over southern Kyushu. The minimum atmospheric pressure reading of 954 mb was recorded at the center of the strom shortly before it reached Kyushu. The pressure began to rise, and as the storm entered the Japan Sea it was downgraded to a tropical storm with associated fronts, and finally assumed the characteristics of an extra-tropical cyclonic storm.

During the middle of the third decade of August, the Siberian migrating highs became noticeably stronger. Hourly data indicate that temperature maxima and minima in Japan became lower as the islands were invaded by these highs. Depressions also deepened with distinctly associated warm and cold fronts. These are the storms that bring rain in sufficient quantity to constitute the Shurin season.

During the first decade of September, the Siberian High attained sufficient strength to equal that of the Ogasawara High. Because of the similarity of strength that existed between these two high pressure fields, a condition conducive to a stationary front arose. The trend of the stationary frontal zone was northeast by southwest with respect to the atmospheric circulation around the Ogasawara High that was situated to the southeast, and the Siberian High that was to the northwest.

The frontal zone was situated along the southern Japanese coastline to approximately the northern Kanto Region. Accordingly, northern Tohoku and Hokkaido were not affected by the oscillation of the stationary front, but receive precipitation from depressions that later developed along this front and moved northeastward and those that developed in Siberia that swung in an arc-like trajectory over Japan.

During this decade of September, Typhoon No. 11 (Bess) moved along a path similar to that of Typhoon No. 10 (Agnes). Tyhpoon No. 11 also entered the Japan Sea and was soon downgraded to a tropical storm and finally to an extra-

tropical depression. According to weather maps, typhoons occur at unpredictable intervals and are totally lacking during some years, but they are considered to be significant contributing factors to the total rainfall during the season.

From the middle of the third decade of September, the stationary front appears to break down as the Siberian High becomes appreciably stronger than the Ogasawara High. Waves are evident along the Polar Front that later develop into troughs that travel northeastward. In addition, synoptic charts show that fronts can from between two migrating highs and swing southward, often creating a double Polar Frontal situation. But, by the end of the second decade of October, the Polar Front has migrated south of the islands of Japan and the weather pattern is clearly dominated by the Siberian High.

2. *500 Millibar Charts*

The 1957 500 Millibar World Weather Maps for the same period indicate that the meridional temperature gradient along the 140th East Meridian remained relatively gentle until the latter part of the second decade of August. Pressure gradient also exemplifies a similar pattern. Surfaces of low pressure during this period were not well defined except for typhoons. Troughs caused by typhoons appeared to be super-imposed on the general isobaric pattern and caused only locally steep gradients. However, it has been suggested that typhoons may have far reaching regional or world wide meteorological effects.[9]

On August 19, temperature and pressure gradients became suddenly steeper as the western edge of the Ogasawara High approached the Pacific Coast of Japan. Simultaneously, an upper-level depression positioned itself over the Sea of Okhotsk. Until this day, wind velocities rarely exceeded thirty kph. After August 19, however, abrupt increases to greater than forty kph were commonplace as the Subtropical jet stream first appeared in the environs of Japan. The jet stream was oriented in an east by west direction over northern Hokkaido and southern Sakhalin. Until this time, the Subtropical Westerlies could not be located at this level and only the Polar jet stream that was located well to the north could be detected on the 500 Millibar charts. On August 23, the confluence of the jet streams was first observed over northern Japan. However, the charts show that even as the Shurin progressed, only one jet stream was discernible during most of the season.

Until early September, alternating ridging and troughing took place in eastern Siberia from depressions that had borken off the great Polar trough. These became increasingly deeper as the days progressed. On September 4, a trough became quasi-stationary in eastern Siberia. This was replaced on September 7 by a general southward migration of the Great Polar trough as it

positioned itself between the 65th and 75th parallels in northeastern Siberia. The depression remained in this general area until mid-October, when it dissipated and once again alternating ridiging and troughing occurred.

On August 28, the center of the Ogasawara High at the 500 Millbiar level shifted abruptly to the east in a manner similar to the cell at the surface. The upper air shift of the high to the east, and the positioning of a trough north of Japan made it possible for the jet stream to swing southward over southern Japan.

North-south oscillation of the steep pressure and temperature gradients and the jet stream was evident. The charts indicate that the southward thrust is long in duration, while the northward pulsation is short-lived. By August 31, the Subtropical jet stream was situated over Akita, and it was found south of Tokyo by September 15. By the 20th of the month, it was situated near Hachijojima, and on October 9 it had progressed southward to Torishima.

During the first half of the Shurin, the migrating highs that were discernible on the surface charts were not evident at the 500 Millibar level, but many were associated with troughs at this altitude. After the middle of the season, these high pressure centers attained great strength as they mgirated offshore over the Pacific.

Precipitation that falls in Japan during this season seems to be associated with low pressure and convergence, steep pressure and temperature gradients, and strong Subtropical Westerlies in the upper atmosphere. On the other hand, fair weather is associated with ridging and divergence, gentle pressure and temperature gradients, and a weak wind flow at the 500 millibar level.

3. Weather Types During the Shurin

Seasonal descriptions can generally be accomplished with a representative weather map. This does not appear to be possible with the Shurin. An analysis of daily sea-level charts and hourly meteorological data shows that no fewer than four distinctive weather patterns occurred during the 1957 season. Precipitation is associated with three of these: typhoons and their downgraded depressions, stationary fronts, and troughs that develop on the Polar Front and in Siberia. The fourth pattern is accompanied by fair weather. A discussion of each of these conditions follows:

1. Precipitation Resulting from Typhoon Influences

1) *Atmospheric Characteristics*: Figure 1 shows the sea-level and 500 Millibar charts for September 6 and 7. Figure 2 represents the hourly meteorological data for Wajima from September 4 to 9.

Typhoon No. 11 (Bess) was downgraded soon after it entered the Japan Sea.

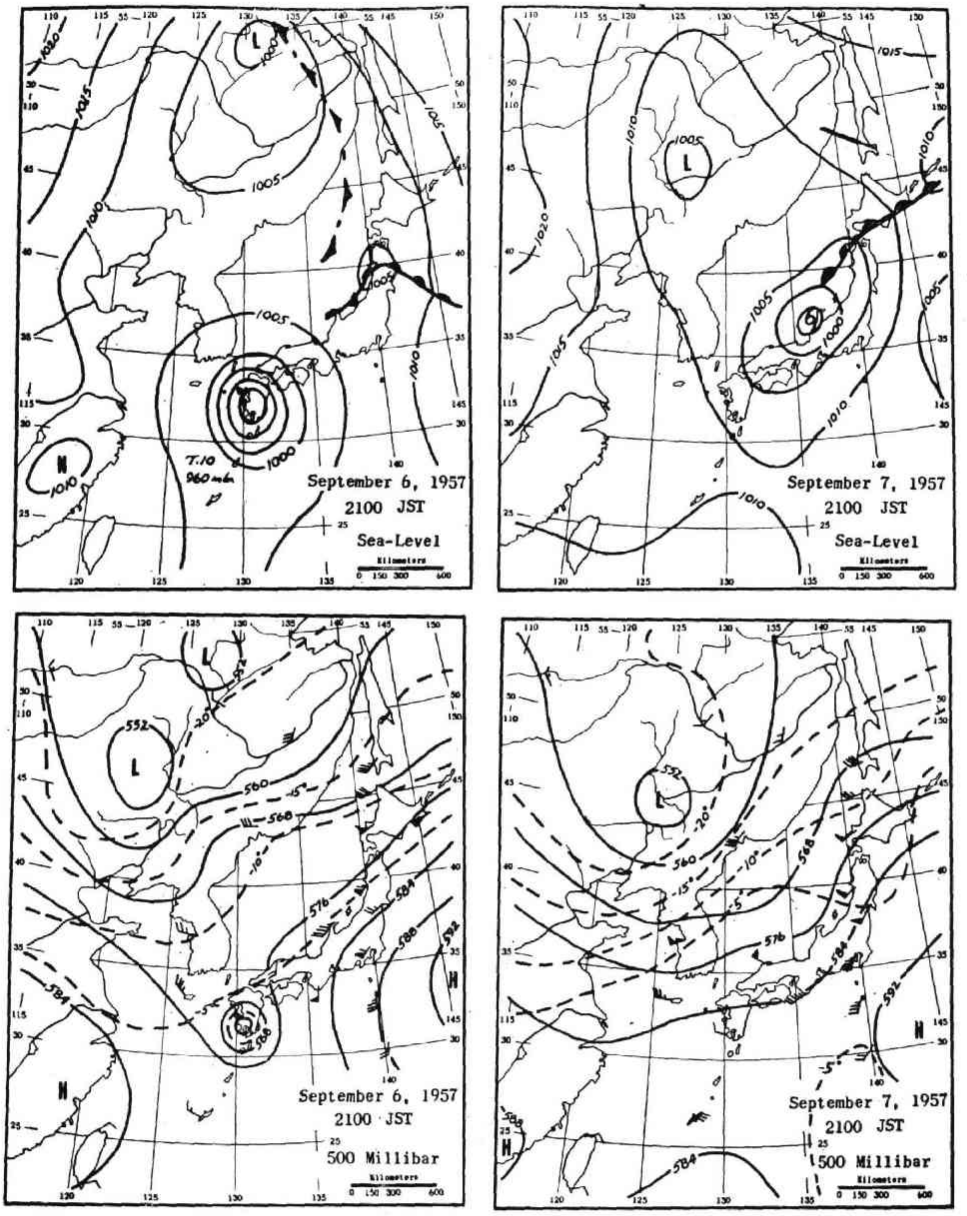

Fig. 1. Source: United States Department of Commerce, Weather Bureau, *World Weather Maps Part 1, Northern Hemisphere Sea-Level and 500 Millibar Charts*, Washington, D.C., September, 1957.

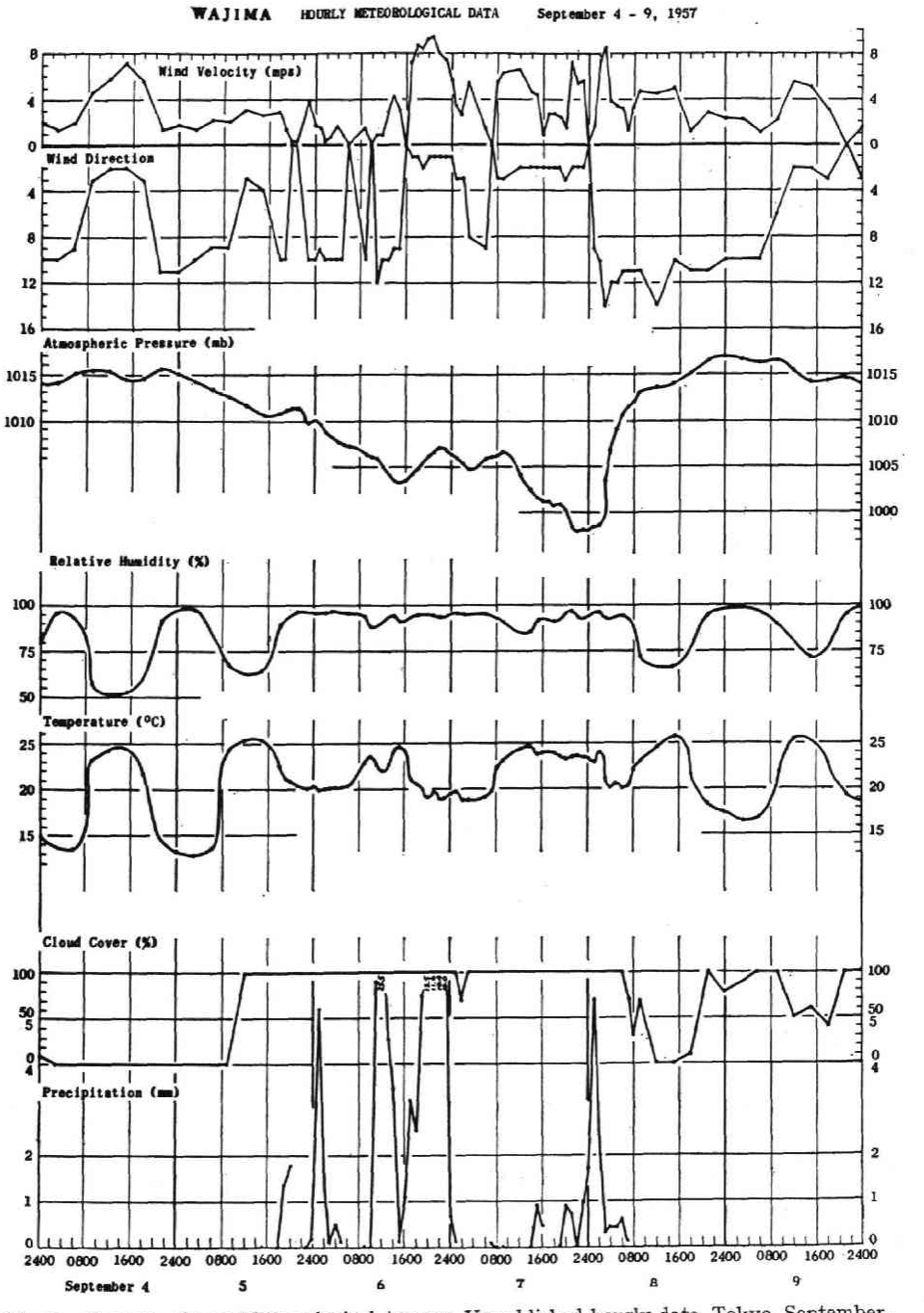

Fig. 2. Source: Japan Meteorological Agency, Unpublished hourly date, Tokyo, September, 1957.

It passed over Wajima at 2200 on September 7. The weather characteristics that resulted are illustrated as follows:

From September 1, Typhoon No. 11 (Bess) remained relatively stationary for five days southeast of Kyushu. A stationary front that extended to the northeast was situated on the northern side of the typhoon for four days. On September 2, a warm front developed, and on September 6 it was joined by a cold front from Siberia. On that day, the typhoon began to move northwestward and the center passed over Kagoshima at 2000 hours on September 6. Atmospheric pressure reading at Kagoshima fell to 968 mb.

After passing over Kyushu, the storm was downgraded to a tropical storm as it skirted the Japan Sea coastline. In the northeast quadrant, a warm front preceded the advance of the storm. The depression then progressed northeastward over Tohoku and along the southeastern coast of Hokkaido. As the storm moved northeastward, wind velocity dimininished and rising atmospheric pressure was evident.

By noting the 500 Millibar charts, one finds the typhoon clearly visible on September 6. However, as it was downgraded on September 7, the trough was no longer discernible at that level. During this period, there existed steep pressure and temperature gradients over southern Hokkaido and northern Honshu. The axis of the Subtropical Westerlies was essentially east by west over this general area. On September 6 and 7, as the depression of the typhoon approached and progressed to the northeast, the area of steep temperature and pressure gradients migrated southward. The axis of the Subtropical jet stream assumed a position southwest by northeast and was situated slightly south of the former axis.

2) *Meteorological Characteristics at Wajima*: Hourly data disclose that from a high of 1015.4 mb on September 4, atmospheric pressure declined steadily to 1003.5 mb soon after a cold frontal passage on September 6. Before the front passed, the wind was predominantly light and from the southwest. After the frontal passage, the wind became northeasterly and the velocity increased to well beyond 7 mps. This lasted until midnight. Table 1 illustrates for selected stations in Japan, the amount, intensity, and the duration of precipitation that accompanied the storm. At Wajima, intense rainfall of 5.8, 25.5 and 4.4 mm per hour fell between the hours of 1100 and 1300, as the cold front passed on September 6. Surface charts show that soon thereafter, the cold front assumed a quasi-stationary position as it merged with a warm front in the northeast quadrant of the tropical storm. A second trough progressed northeastward and the front again affected Wajima. 5.5, 12.5, 11.6, 10.6 and 10.0 mm of precipitation per hour fell from 1900 to 2300 hours.

Table 1. Precipitation characteristics related to typhoon influences September 5–8, 1957

	Millimeters of Precipitation (in hrs.)							Total Hours	Total Precip. (.1 mm)
	0	T-2	2-3	3-4	4-5	5-6	6+		
Akita	29	26	5	3	2	—	7	72	1045
Wajima	17	33	2	2	1	3	5	63	1125
Izuhara	5	19	—	—	—	—	—	24	32
Nemuro	18	24	2	2	—	1	2	49	686
Miyako	11	32	1	2	—	—	3	49	577
Tokyo	12	21	5	4	—	—	2	44	482
Osaka	32	26	2	1	—	—	3	64	605
Kagoshima	12	30	2	2	—	1	7	54	900

Source: Japan Meteorological Agency (unpublished hourly data)

Atmospheric pressure then rose to 1006.5 mb during the mid-morning of September 7, and began to fall rapidly to 998 mb as the center of the now downgraded typhoon passed over Wajima at 2200 hours on September 7. Atmospheric pressure is noted to have risen sharply as a migrating high positioned itself behind the depression. During this period, the wind was from the northeast and was only intermittently calm. Wind velocities were in excess of 6 mps throughout the day. As the center of the tropical storm passed, the wind increased to over 8 mps. After the passage of the depression, wind direction shifted to the northwest, west, then to the southwest. Precipitation was not intense during the actual passage of the trough, but registered 5.5 mm for the hour form midnight to 0100, September 8. Soon thereafter, a clearing trend occurred.

The sky remained completely overcast from mid-day of September 5 until the strom system was out of range to the northeast. Clearing began during the morning hours of September 8, coincident with the abrupt and rapid rise of atmospheric pressure.

Temperature characteristics appeared to be normal until the sky was completely overcast on September 5. Thereafter, temperature declined to only 20.5° from a maximum of 25.3°C. The maximum for the following day was 24.5°C at 1500 hours, when rain was falling. On the succeeding day, nocturnal cooling reduced the temperature to slightly below 20°C, and again daily heating raised the temperature to 24.7°C at 1400 hours, when it was not raining. Although the daily pattern of temperature was retained to some extent, the magnitude of the maxima and minima was redued considerably during this period of precipitation.

Relative humidity was constantly high throughout the storm, generally exceeding 90%. During the interim period of precipitation at 1400 hours on September 7, relative humidity was reduced to approximately 85%, but declined

sharply after the storm system passed, and assumed a normal pattern.

3) *Conditions at Other Areas in Japan*: As noted above, a minimum pressure reading of 968mb was recorded at Kagoshima at 2200 hours on September 6, as the typhoon passed. Hourly data show that from 1500 through 2100 hours, 52 mm of precipitation fell in seven consecutive hours. The eastsoutheast wind immediately shifted its course westnorthwesterly as the center of the storm passed with exceedingly high wind velocities. Maximum wind velocity of 21.4 mps was recorded at 1800 hours on September 6. For seventeen consecutive hours, the wind raged at slightly below to more than 20 mps, and the wind was blowing at speeds greater than 8 mps throughout the storm. The temperature remained constantly between 24° to 27°C.

The environs of Tokyo and Osaka were spared the brunt of the storm, since the typhoon entered the Japan Sea. The areas along the Pacific Coast felt only the weather fronts that were associated with the tropical storm. Atmospheric pressure dipped slightly below 1000 mb at Tokyo. In addition, precipitation was short in duration and was momentarily intense as the fronts passed. Wind velocities approached 12 mps with the passing of the front. Osaka experienced a constant northeast wind that became southerly as the trough migrated to the northeast. Tokyo on the other hand, had southsoutheast and southerly winds.

Conditions at Miyako were similar to those previously described for Wajima. A cold front from Siberia that was oriented northeast by southwest affected Miyako on September 6. Precipitation was generally light; however, at 1300 the recorded precipitation figure was 6.0 mm. The wind was extremely light and the direction varied from southeast to westerly. The cold front then merged with a warm front that extended northeastward from the tropical storm and formed a secondary trough that moved to the northeast, preceding the tropical storm. Although the wind velocity was light, the wind altered its direction to the northeast. As the secondary trough with associated fronts passed, 6.7 mm of precipitation fell. The northeast by southeast oriented cold front that was associated with this trough oscillated as Miyako was again influenced by the system that had passed ten hours previously. Heavy precipitation was experienced at 1400 on September 7, when 14.7 mm fell. Thereafter, precipitation diminished to below 2 mm per hour as the former typhoon depression passed to the north and wind velocities increased to over 7 mps for three hours beginning at 2300, September 7, when atmospheric pressure declined to 998.1 mb. By 0800 the following day the depression was well to the northeast. Miyako experienced only a slight temperature range throughout the storm. The temperature range was a mere 3°C. and the average temperature was approximately 20°C. for the course of the storm.

The hourly data for Nemuro and the surface charts show that while central and northern Honshu were experiencing a single storm, Nemuro had two distinct periods of precipitation, separated by seventeen hours. As the downgraded typhoon approached from the southeast, wind direction was from the east, with gusts up to 11 mps. Precipitation became intense as 15 and 16 mm fell for two hours beginning at 0600 on September 8. Atmospheric pressure declined to 996.3 mb at 1200 of the same day, as the wind became northwesterly.

Approximately thirty-six hours previously, this strom had been an intense typhoon that devastated Kagoshima. By the time it reached Nemuro, it had assumed conditions similar in every respect to other extra-tropical cyclonic storms.

2. Precipitation Resulting From a Stationary Frontal Condition

1) *Atmospheric Characteristics*: Figure 3 shows the sea level and 500 Millibar conditions for September 9 and 10. During this period, a stationary front was situated along the southern Japanese coastline and was influencing the weather of central and southwestern Japan. Figure 4 depicts the hourly meteorological data at Tokyo for the period between September 8 and 13.

At the 500 Millibar level, steep gradients in both pressure and temperature were in existence as an upper-level depression was situated over eastern Asia. The axis of the strong subtropical jet stream was westsouthwest by eastnortheasterly over central and northern Japan; however, the velocity appears to have diminished on September 11, as the trend of the Westerlies became southwest by northeasterly. Coincidentally, both the steep pressure and temperature gradients are noted to have become gentle. This condition took place as the upper-level trough migrated to the east. At the same time, the Polar jet stream became more prominent. Confluence between the two jet streams seems to be increasingly evident from mid-September as the Subtropical jet once again became strong, and a deep trough settled over eastern Asia.

2) *Meteorological Characteristics at Tokyo*: Hourly data show that from a low of 1004.4 mb that was recorded during the early morning hours of September 8, atmospheric pressure steadily rose to 1013.6 at 0900 hours on September 9. Until this time, the wind was from the south, but the direction abruptly shifted to the north and northwest as the front approached, and wind velocity diminished to an average of about 3 mps during the same period. Atmospheric pressure reading remained relatively constant for the next three days while the stationary front was influencing the southern coast. This front trended northeast by southwest. Surface charts indicate that the front developed because the Siberian Migrating High and the Ogasawara High were approximately of the same strength. As this condition persisted, there was little change in the position of the stationary front.

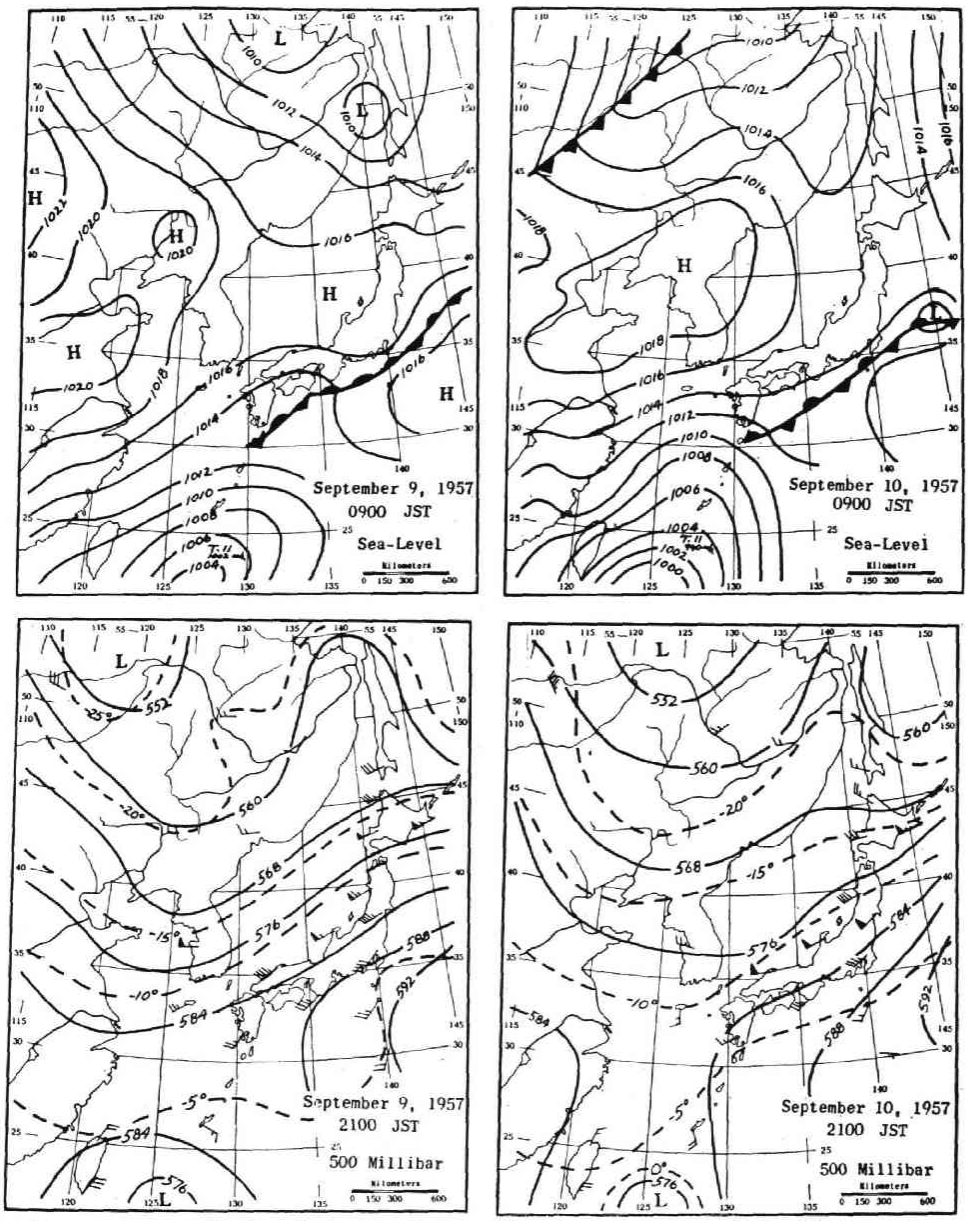

Fig. 3. Source: Sea-Level charts: Japan Meteorological Agency, *Daily Weather Maps*, Tokyo, September, 1957. 500 Millibar charts: United States Department of Commerce, Weather Bureau, *World Weather Maps, Part 1, Northern Hemisphere Sea-Level and 500 Millibar Charts*, Washington, D.C. September, 1957.

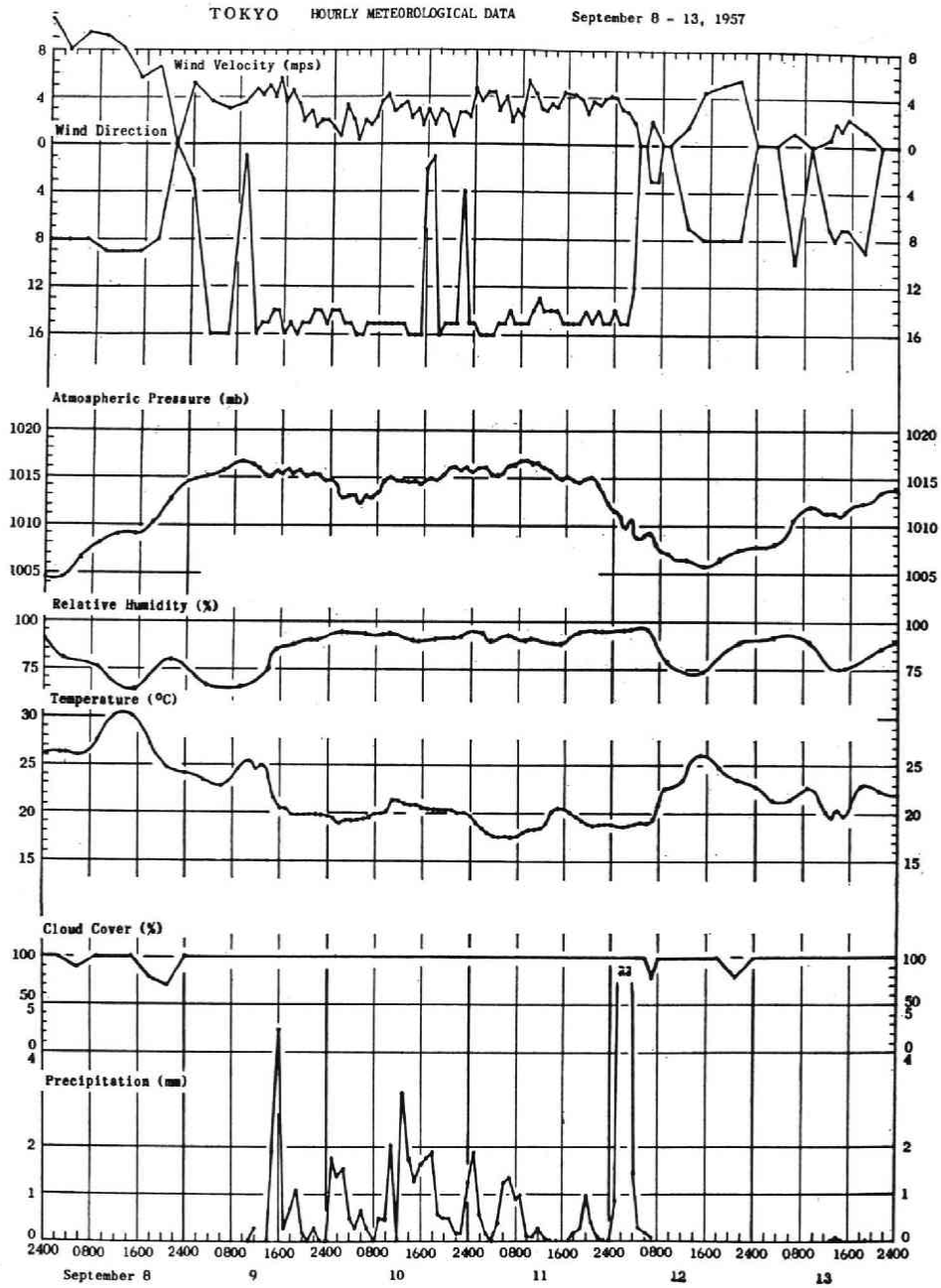

Fig. 4. Source: Japan Meteorological Agency, Unpublished hourly data, Tokyo, September, 1957

Pressure began to decline on the front as a depression developed and the mgirating high moved northeastward. The trough passed north of Tokyo at 1200 hours on September 12, when the pressure reading fell to 1006.4mb. At that time, the wind shifted to a southerly direction and the velocity increased to over 5 mps for seven hours.

Sea-Level charts illustrate that the dissipation of a stationary frontal condition appears to take place as waves form on the front. The new system with associated warm and cold fronts migrate to the northeast. With the passing of the storm, clear sky conditions are evident in areas that were most affected.

During the Shurin of 1957. Synoptic charts show that stationary frontal conditions were not experienced on the Japan Sea Coast north of Tsuruga, the extreme northeastern portions along the Pacific Coast of Tohoku, or in Hokkaido. It was, however, observed that this condition influenced the weather from central to southwestern Japan during numerous occasions.

Table 2 depicts the precipitation characteristics for selected stations in Japan during this period. At Tokyo, a total of 62.2 mm of rain fell in 69 hours. The table indicates that the intensity of precipitation was extremely light, since 61 hours consisted of precipitation of less than 2mm per hour, while rainfall exceeded 6 mm for only two hours from 0200, September 12, as the cold front and the depression moved to the northeast.

Hourly data indicate that during the course of precipitation, the average temperature was 19.9°C. This represented a figure of 0.2°C lower than the average minimum temperature for five-day periods before and after the storm. Undoubtedly, this condition was caused by the predominant northwesterly winds that prevailed during this period. Moreover, the temperature range was only 3.7°C.

Relative humidity remained constantly high. On the average, the figures

Table 2. Precipitation characteristics related to a stationary frontal condition September 9–12, 1957

	Millimeters of Precipitation (in hrs.)							Total Hours	Total Precip. (.1 mm.)
	0	T-2	2-3	3-4	4-5	5-6	6+		
Akita	19	18	—	1	—	—	—	38	120
Wajima	1	8	1	3	—	1	2	16	392
Izuhara	25	8	—	—	—	—	—	33	5
Nemuro	1	10	1	1	—	—	1	14	257
Miyako	32	22	2	2	1	—	2	61	538
Tokyo	4	59	2	1	1	—	2	69	626
Osaka	1	55	6	3	1	3	4	73	1035
Kagoshima	4	33	10	3	2	3	4	59	1136

Source: Japan Meteorological Agency (unpublished hourly data)

were in excess of 90%, and did not drop below 88% at any time.

3) *Conditions in Other Areas of Japan*: Sea-level charts and hourly data disclose that conditions at Osaka were similar to those of Tokyo, with the exception of the predominantly northeasterly wind. Temperature was also lower than normal, and the range was as limited as that for Tokyo.

Table 2 indicates that precipitation at Kagoshima was slightly more intense than that for Tokyo. In this respect, Osaka and Kagoshima show similar characteristics. The wind was constantly from the northeast, but the velocity steadily increased to 12.7 mps at 2000 hours on September 10, and thereafter it declined steadily. Synoptic charts show that the high wind was caused by the passage of the depression and the fronts.

Miyako was at the extreme northern fringe of the stationary front. As such, the effects were minimal. At the time when atmospheric pressure was in excess of 1015 mb, very light precipitation fell for but 5 hours. However, relative humidity was high, the sky was completely overcast, temperature range was only 3.5°C., and although the average temperature was low, a greater daily heating and cooling trend prevailed than for either Tokyo or Osaka. These conditions persisted until the depression passed to the northeast, some 48 hours later.

Because Miyako was affected only mildly by the stationary front and later by the depression that developed on the front, it appears that there were two storms. This, however, was not the case. Synoptic charts and hourly meteorological data show that a single storm affected Miyako twice. At first the stationary front mildly affected the area, then a trough was formed on the front and soon thereafter passed through the Miyako area.

Neither Wajima and Nemuro was influenced by the stationary frontal condition. Although the storm affected these two areas, the storm origin was related to the depression that developed on the stationary front. By the time the trough reached these areas, the center had sufficiently deepened to that reminiscent of other extra-tropical cyclonic storms with associated fronts. Precipitation was short in duration and intense for a few hours when the cold front passed.

3. Precipitation Resulting from an Extra-Tropical Storm with Associated Fronts

1) *Atomospheric Conditions*: Figure 5 shows the sea-level and 500 Millibar atmospheric conditions for October 6 and 7. On October 5, a wave developed on the Polar Front southwest of Kyushu in the East China Sea. The depression moved northeastward and influenced the weather of the entire country. Figure 6 depicts the hourly meteorological data for Miyako for the period between October 4 and 9.

According to the 500 Millibar level charts, after the fair weather conditions

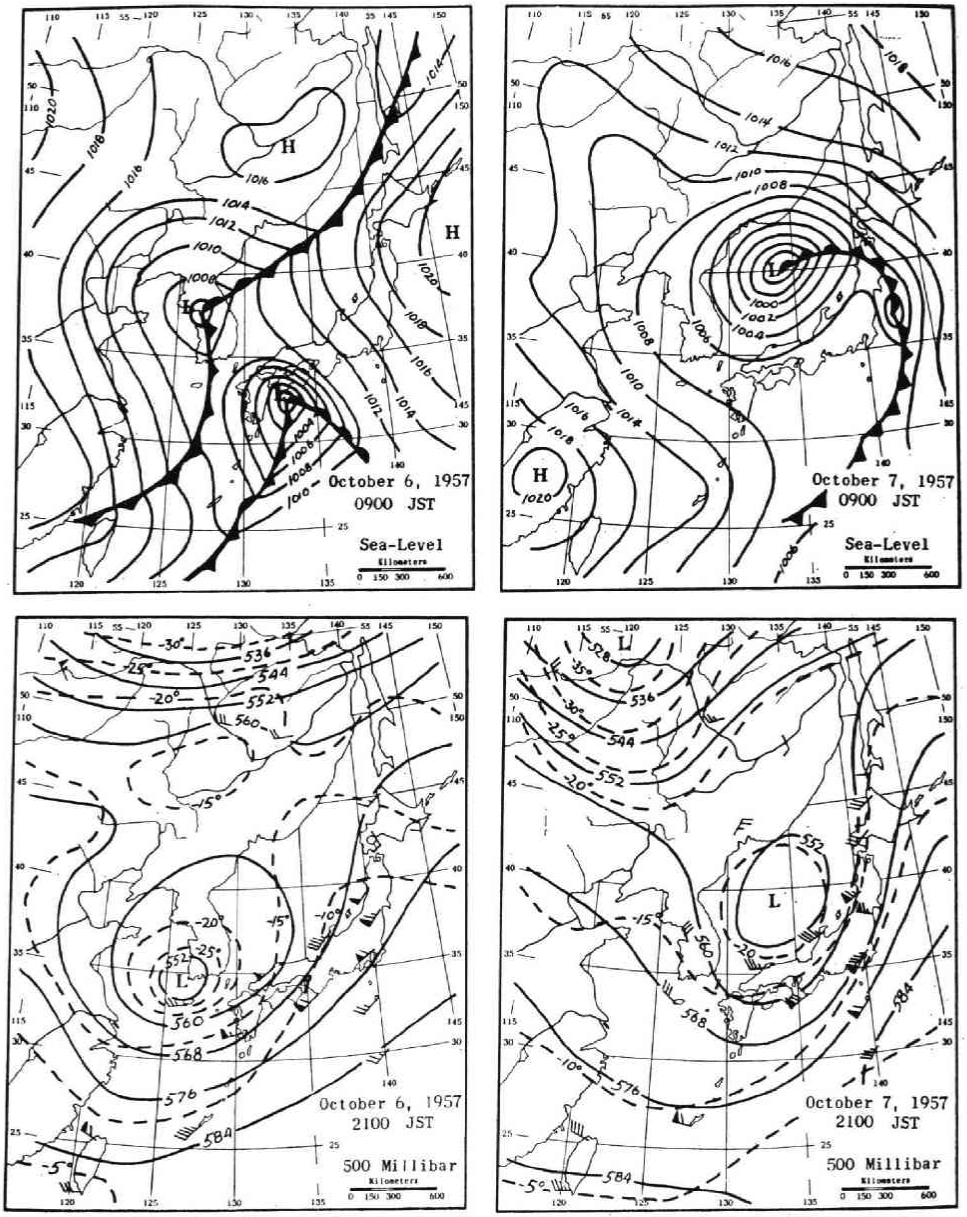

Fig. 5. Source: Sea-Level charts: Japan Meteorological Agency, *Daily Weather Maps*, Tokyo, October, 1957. 500 Millibar charts: United States Department of Commerce, Weather Bureau, *World Weather Maps, Part 1, Northern Hemisphere Sea-Level and 500 Millibar Charts*, Washington, D.C. October, 1957.

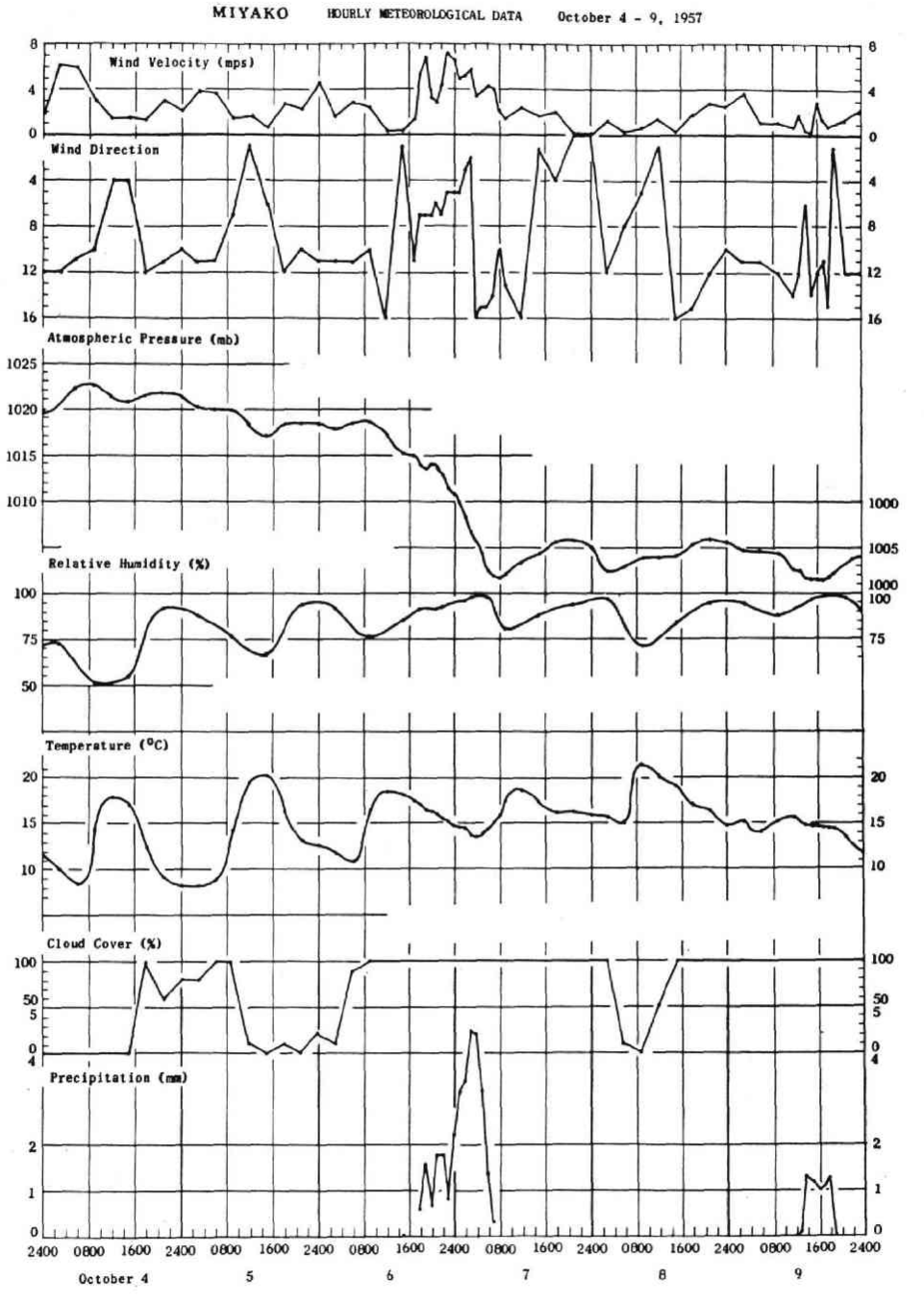

Fig. 6. Source: Japan Meteorological Agency, Unpublished hourly data, Tokyo, October, 1957

ended on October 5, a low pressure center became situated over southern Manchuria and Korea. As this center progressed northeastward, extremely steep pressure and temperature gradients were created over central and southwestern Japan. The axis of the Subtropical Westerlies trended northeast by southwest over central and southwestern Japan, with an extremely high wind velocity. The confluence area between the northern and southern jets appears to have been in the vicinity of the Okhotsk Sea. Fair sky conditions returned after the center of the trough progressed well to the northeast of Hokkaido, as both the temperature and pressure gradients became gentle and the Subtropical Westerlies decreased in strength.

2) *Meteorological Characteristics at Miyako*: To illustrate the weather conditions associated with this type of a storm during the Shurin, the hourly meteorological data for Miyako will be used. It has been noted that this type of a precipitation condition is the most prevalent during the Shurin, especially in Northern Japan. Torpical storms, and wave cyclones that form along the stationary front invariably affect northern Tohoku and Hokkaido as just such a depression with associated fronts.

Synoptic charts show that the trough that affected Japan on October 6 and 7 originated on the Polar Front, southeast of Kyushu. This trough progressed to the Pacific side of Japan, off the coast of Shikoku and skirted to the Japan Sea, where it joined another depression that originated in Siberia, and occlusion occurred rapidly. The trough then proceeded northeastward through Hokkaido, to the North Pacific Ocean.

At Miyako, as the depression approached and the migrating high pressure cell moved offshore, pressure began to fall rapidly. The southwest wind, with an average velocity of approximately 2.5 mps, became north and northeasterly, with diminishing force for several hours before the center of the trough and the occluded front passed. At 1600, October 6, two hours before precipitation started, the wind shifted to the southeast quadrant as velocity increased to approximately 7 mps. Precipitation began as atmospheric pressure fell rapidly. The occluded frong passed at 0800 hours on October 6, as the pressure reading fell to 1001.9 mb. However, the wind shifted to the northwest direction at 0400 hours of the same morning.

Table 3 illustrates the precipitation characteristics for selected stations in Japan for this period. At Miyako, a total of 29.9 mm fell in 17 hours. Precipitation was not intense, since the trough passed to the north and the front was in the state of occlusion. Hourly data indicate that the maximum intensity was recorded between 0300 and 0400 hours, October 7, when 4.5 and 4.4 mm of rain fell

Table 3. Precipitation characteristics related to an extra-tropical storm October 4–7, 1957

	Millimeters of Precipitation (in hrs.)							Total Hours	Total Precip. (.1 mm.)
	0	T-2	2-3	3-4	4-5	5-6	6+		
Akita	61	32	4	—	2	—	2	101	484
Wajima	4	13	4	—	—	2	1	24	402
Izuhara	5	4	—	2	—	—	—	11	80
Nemuro	11	14	1	2	1	—	1	30	304
Miyako	4	8	1	3	2	—	—	18	299
Tokyo	1	5	1	1	1	—	7	16	827
Osaka	6	14	1	—	—	—	—	21	98
Kagoshima	20	28	3	4	—	1	2	58	495

Source: Japan Meteorological Agency (unpublished hourly data)

respectively, while for most of the storm less than 2 mm per hour were recorded.

The maximum temperature recorded on October 6 was 18.5°, and the minimum that followed was 13.6°C., recorded at 0400 hours. The temperature then began to rise to 18.7°C. at 1200. It should be noted that although the sky was overcast, precipitation was not falling when the maximum temperatures for October 6 and 7 were recorded. Precipitation fell during the evening and early morning hours. Because of the overcast conditions, temperature maxima were lower than on the days that preceded and on the days that followed. For the same reason, the minima were higher than on those days preceding and following.

As the sky became completely overcast at 0900 on October 6, relative humidity began to rise from a minimum of 76%. During the time of greatest precipitation intensity, relative humidity reached 99%, and rapidly decreased to 81% at 0900 hours on October 7. Because of the overcast conditions, it did not fall to a lower figure during that day.

3) *Conditions at Other Areas of Japan*: At Kagoshima, atmospheric pressure declined rapidly as the depression approached. The wind was predominantly from the northeast, with a velocity of 2.0 mps. As precipitation began to fall ,wind velocity increased to over 5 mps, and as the warm front passed, precipitation reached 6.2 mm per hour for the period between 2200 and 2300 hours on October 5. A trace of rain was recorded for two hours beginning at 2400 hours, when the warm sector approached. With the passing of the warm sector, the wind became northerly, then northeasterly, with gusts approaching 7 mps as the cold front advanced. Atmospheric pressure then declined to 1005.9 mb, and precipitation again resumed. Intense precipitation of 8.0 and 5.2 mm fell for two hours, commencing at 0500 on October 6. At 1200 hours of the same day, the center of the trough was well to the northeast and precipitation ceased.

Temperatures averaged approximately 19.5°C. throughout the storm. The maximum recorded temperature during the period of precipitation was 19.6° and the minimum reading was 18.1°C. The temperature range, therefore, was slight.

The calm to northwesterly winds at Tokyo assumed an easterly direction four hours after precipitation began. The velocity then increased to slightly over 4 mps. As the center of the depression approached, atmospheric pressure declined rpaidly. At 0800 hours, October 6, pressure reading was 1016.2 mb, but at 2400 hours of the same day the reading fell to 1001.4 mb. Although precipitation began to fall at 0600, extremely intense rain fell during the seven hours beginning at 1400 hours. The hourly figures were as follows: 8.4, 7.6, 10.2, 13.4, 11.4, 12.6 and 5.6 mm per hour. As noted for Kagoshima, the temperature range at Tokyo was also limited and relative humidity was constantly in excess of 90%.

The trough traversed central Japan and slipped to the Japan Sea, where it was joined by another low pressure system. At Wajima, the wind was from the southwest, with velocities of less than 2 mps. As atmospheric pressure began to fall abruptly, the wind shifted to the northeast, with gusts exceeding 8 mps. Extremely intense precipitation of 12.4 mm fell for one hour beginning at 1800 hours on October 6 as the system approached. Atmospheric pressure reading fell to 999.3 mb three hours later as the depression passed. The wind then shifted to a southwesterly direction with strong gusts exceeding 8 mps, as light precipitation fell. As noted for Kagoshima and Tokyo, the temperature range at Wajima remained slight; however, relative humidity oscillated between 85 and 93% several times during the evening and in the early morning hours.

Conditions at Nemuro were about the same as those previously described for Wajima. However, before precipitation began, wind direction was constantly from the southsoutheasterly direction with moderate wind velocities averaging 6 mps. As the trough approached, the direction gradually shifted to a southerly, then for most of the period, southeasterly winds were in existence. At the time of precipitation and the lowest atmospheric pressure reading, the wind exceeded 10 mps for several periods, and on occasion approached 16 mps.

4. Conditions During Clear Weather

1) *Atmospheric Conditions*: Figure 7 shows the sea-level and 500 Millibar atmospheric conditions for October 3 and 4. At this time, all of Japan was experiencing clear weather conditions. Figure 8 depicts the hourly meteorological data for Kagoshima for the period between September 30 and October 5.

As illsutrated by the 500 Millbiar level charts, a divergence pattern settled over Japan from the west on October 3 and 4. Both the temperature and pressure gradients became extremely gentle, and the Subtropical Westerlies diminished in

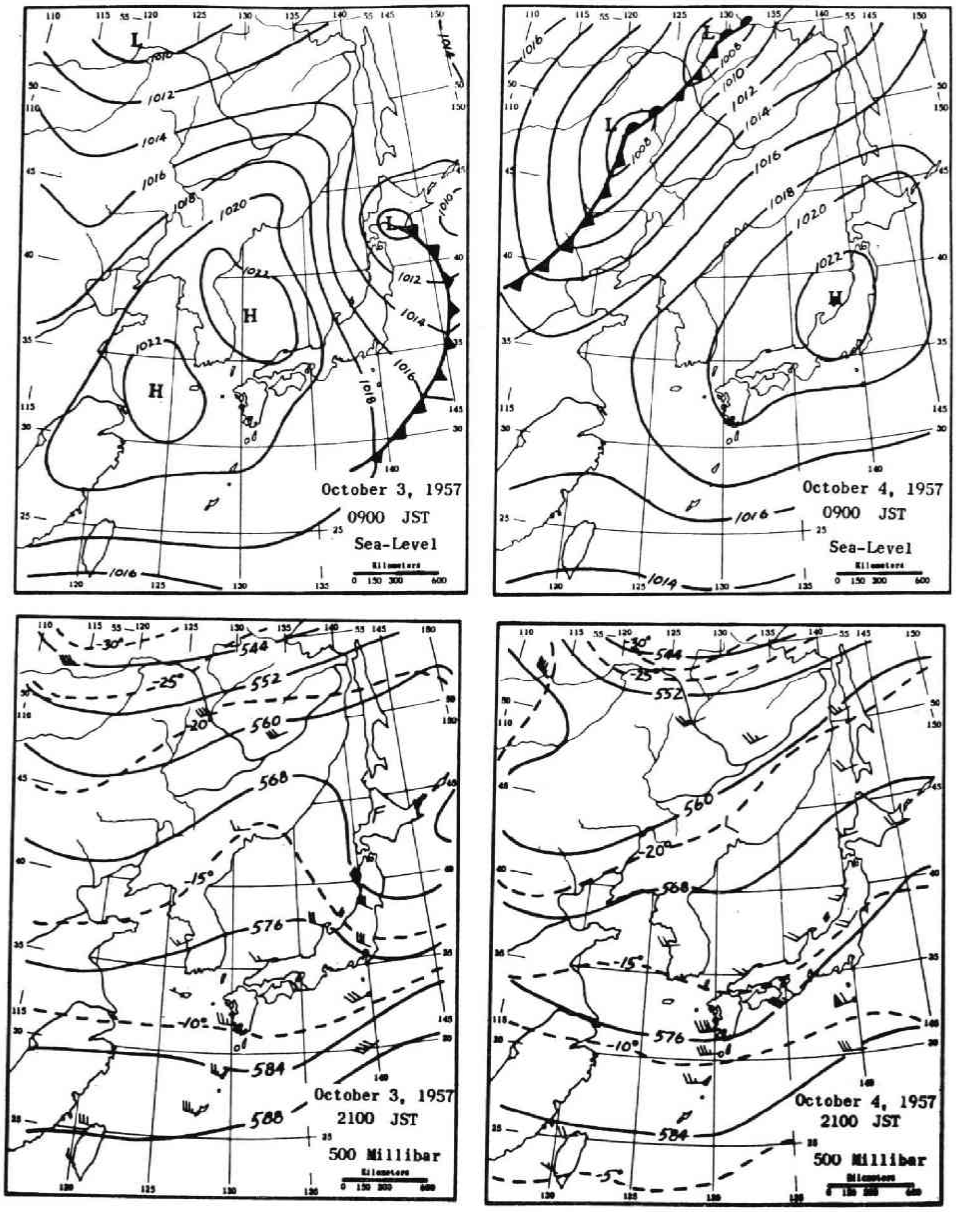

Fig. 7. Source: Sea-Level charts: Japan Meteorological Agency, *Daily Weather Maps*, Tokyo, October, 1957. 500 Millibar charts: United States Department of Commerce, Weather Bureau, *World Weather Maps, Part 1, Northern Hemisphere Sea-Level and 500 Millibar Charts*, Washington, D.C. October, 1957.

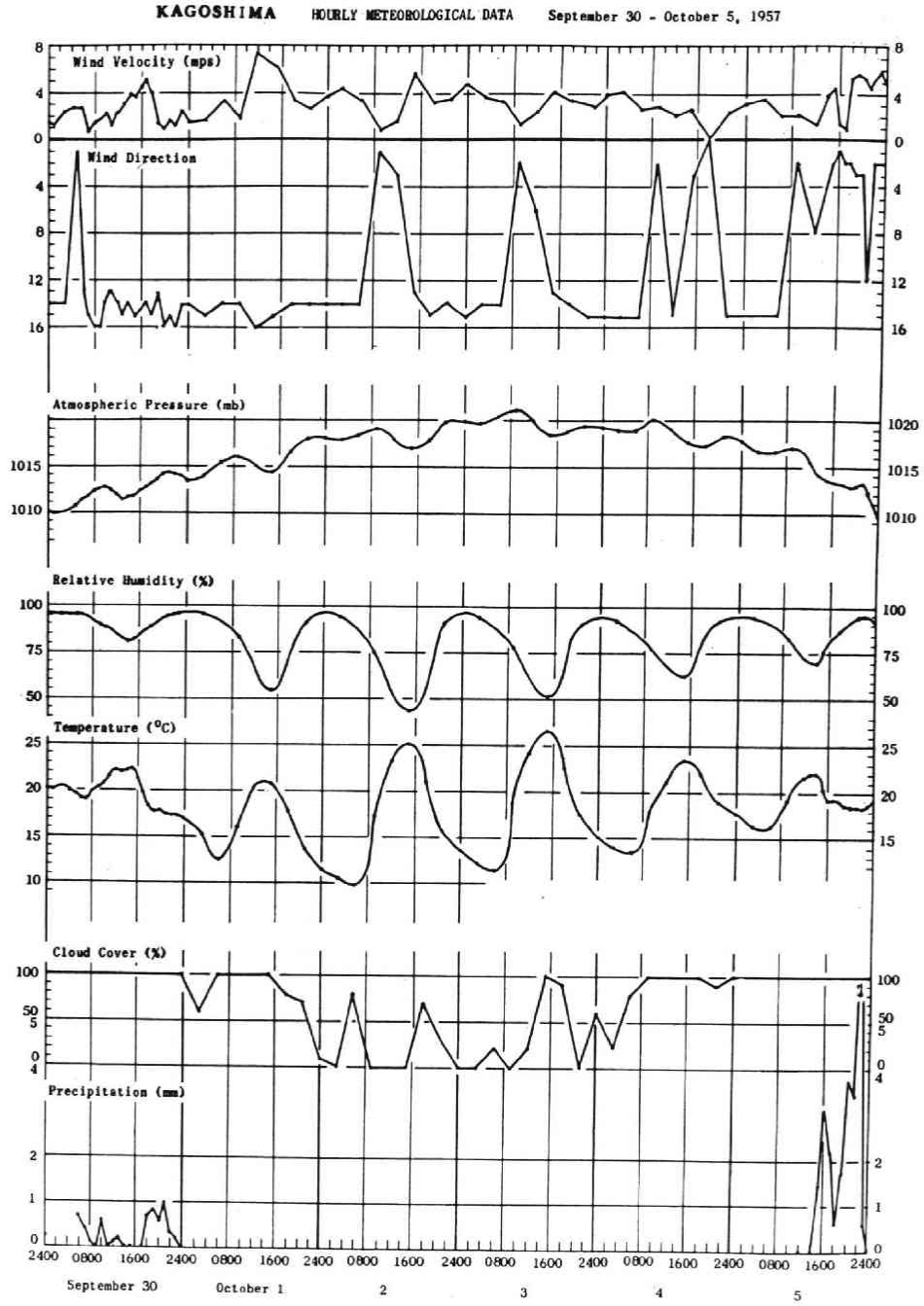

Fig. 8. Source: Japan Meteorological Agency, Unpublished hourly data, Tokyo, October, 1957.

force, while the Polar jet stream was well to the north. During this period, all of Japan enjoyed fair weather. This system progressed to the east, and the fair condition deteriorated soon thereafter, as a surface depression developed south of Kyushu and an upper-level trough settled over Korea.

2) *Weather Conditions at Kagoshima*: To illustrate the weather picture associated with this type of pattern, hourly meteorological data for Kagoshima will be utilized. Throughout the season, fair conditions prevalied in Japan at intervals between periods of precipitation, but their frequency was greater toward the end of the season. As a Siberian migrating high pressure cell settled over Japan, the Polar Front migrated southward, and as the cell progressed to the northeast, the front again returned to influence the weather over Japan.

After precipitation that lasted for more than two days ended on September 30, atmospheric pressure began to increase steadily from a low of 1009.7 mb, recorded at 0100 hours, September 30, to 1021.1 mb, as a continental migrating high settled over Japan. Thereafter, pressure declined at a uniform rate until just a few hours before a trough passed.

During this period, the sky was clear. From 1500 hours on October 1, a general clearing trend occurred. The sky seldom had over 50% observed cloud cover and it was cloudless much of the time. From 0600, October 4, cloudiness increased, and within three hours the sky was completely overcast.

An extremely wide temperature range is evident for this period. The average minimum temperature for the two days, October 2 and 3, was 10.5°C., while the average maximum for those two days was 25.9°C. This represents a range of slightly over 15°C., suggesting strong nocturnal cooling and daytime heating. Relative humidity also shows a great variation between early morning and mid-afternoon hours. For example, relaitve humidity dropped to 43% at 1500 on October 2, from a high of 94% that was recorded on the same day at 0300 hours.

The wind was predominantly from the northwest, but for a few hours from 0900 hours, the direction was from the northeast and eastnortheast. Since this condition lasts until mid-afternoon, it was probably due to the difference in temperature that developed at Kagoshima and over the adjacent bay. Moreover, a similar pattern was noted during other periods when Kagoshima was being influenced by both the Ogasawara and the Siberian Highs. This trend was more pronounced, however, under the dominantion of the Siberian High. It appears that during the evening and early morning hours when the northwesterly winds were prevailing, the velocity was the strongest, recording a maximum of about 4 mps. While the northeasterly winds were persisting, the wind was nearly at a calm condition, registering, at the most, 2 mps.

3) *Conditions at Other Areas in Japan*: Synoptic charts indicate that because the continental migrating high pressure cell first invaded Kyushu, other areas in Japan experienced a similar condition one to two days later. Hourly data show that weather characteristics were similar to those reported for Kagoshima. Atmospheric pressure was only slightly higher for stations north of Kagoshima. Temperature range was also great, with a strong tendency for nocturnal cooling and daytime heating.

Along the Pacifc coast, however, from Osaka to northeastern Tohoku, relative humidity appears to be appreciably lower than the figure recorded at Kagoshima. For example, the minimum relative humidity for Tokyo on October 3 was 33%, recorded at 1500, while the maximum reading on the following day, recorded at 0300 hours, was only 66%, while Kagoshima and the remainder of Japan had readings in excess of 90%.

The greatest variation between the weather characteristics at Kagoshima and those at other stations in Japan was in wind direction and velocity. Kagoshima is situated adjacent to a large body of water as are several of the other stations throughout Japan. However, Kagoshima is the only reporting station where a distinct directional pattern was noted. This pattern was evident only to a minor degree elsewhere. Wind velocity everywhere appears to resemble that for Kagoshima, except at Tokyo, where it increased to an excess of 6 mps and to a maximum of 8.5 mps from mid-morning to mid-afternoon of October 3.

Conclusion

Daily meteorological patterns for August, September and October, 1957 through 1961, compared with the patterns of average daily values revealed that the 1957 season most closely resembled the average Shurin. Accordingly, the 1957 season was assumed to be the most representative. Because data and patterns for only a period of five years were examined, inadequacies resulted and certain trends did not conform to the normal.

During the pre-Shurin period of 1957, the surface isobaric pattern in eastern Asia was unifrom, with only weak fronts separating the continental from the Pacific air. After the beginning of the season, depressions that originated on the Polar Front in the East China Sea advanced northeastward through the vicinity of Japan. And troughs that developed in Siberia progressed southeastward, then to the northeast in an arc-like manner over Japan during their course to the North Pacific. Most of the storms that influenced Japan during the 1957 Shurin were primarily related to these two types.

It was not in the scope of this report to determine when the breakdown of the isobaric uniformity in eastern Aasia occurred. Historical charts showing the

changing isobaric pattern both at sea-level and the upper atmosphere should prove not only interesting but worthwhile. Partial explanations have been presented by Suda[10] and Asakura[11].

At the 500 Millibar level, increased wind velocity of the Subtropical jet stream was evident from August 19, as a trough settled over the Okhotsk Sea. Soon thereafter, confluence between the Polar and the Subtropical Westerlies began to take place in the vicinity of northern Japan. However, confluence did not occur in the environs of Japan to the extent that was originally assumed. In early September, a depression settled over eastern Siberia and the Subtropical jet stream migrated southward. The upper atmosphere involved an analysis of only the 500 Millibar level charts. Because of non-availability, charts representing higher altitudes were precluded. Undoubtedly, an analysis of higher level charts would have proved fruitful. Moreover, the Subtropical Westerlies were not always discernable during the early stages of the season at the 500 Millibar level, and charts of higher altitudes would have aided in their location.

This report illustrates the four distinct weather patterns that were discovered to be in existence during the 1957 Shurin. Three were associated with precipitation and one with fair weather. Based on a thorough examination of the 1957 synoptic charts, it is assumed that no other types exist during the Shurin season. Although three storm types and a fair weather pattern that occurred in 1957 were used as illustrations, they should not be considered as being absolutely representative. The 1957 season resembled the average Shurin, but data for only five years were used in this determination and many irregularities were noted. Truly representative examples of each pattern showing their effects in various parts of the country can be ascertained by an analysis of data and charts for many years. The four weather patterns that influenced the 1957 Shurin are arranged in sequence of their occurence:

1. During the 1957 Shurin, precipitation resulting from typhoons and their downgraded depressions was rare. Sea-level charts for other years indicate that increased typhoon activity and widespread precipitation can result. Significant quantities of intense rainfall associated with high wind velocity characterize this type of weather pattern. Although their effects are short-lived, this represents the most intense type of weather during the Shurin. In the southwestern poritions of Japan, these storms strike as typhoons, but by the time they migrate to northen Japan, they are downgraded and their effects are correspondingly reduced, however violent they may remain.
2. A stationary frontal condition arose during the first decade of September, when the Siberian High became as strong as the Ogasawara High. This condition

prevailed until the third decade of September, when the strength of the Siberian High surpassed the pressure of the Ogasawara High. Precipitation during such conditions is characterized by gentle drizzles, long in duration. Because the front is situated along the southern coastline, its significance is restricted to central and southwestern Japan. Weather associated with stationary fronts did not influence areas along the Pacific coast of northern Tohoku and north of Tsuruga along the Japan Sea coast during 1957. The importance of stationary frontal stroms to the northern areas is related to the wave cyclones that develop and move northeastward, influencing the weather of all of the islands. Characteristics of wave cyclones are similar to those of the type discussed in the following paragraph.

3. The most prevalent precipitation condition during the Shurin of 1957 was associated with cyclonic depressions with warm and cold fronts. These storms originated on the Polar Front, including the aforementioned stationary front in the East China Sea, and in Siberia. These extra-tropical storms affected all of Japan but were more prevalent in the northern areas because both storms that developed along the Polar Front and in Siberia invariably traversed the north. These storms are characterized by being short in duration with locally intense rainfall. An analysis of the percentage of storms that originated on the Polar Front and Siberia was not determined. Such a study combined with regional influences of these storms may be of value.
4. The fourth type of weather pattern was associated with clear conditions. At such times, the Siberian High completely dominated Japan, and an upper-air divergence pattern was evident. The Polar Front was located well to the south of the Japanese Islands and cloud cover and relative humidity were low; and nocturnal cooling and daytime heating created a wide temperature range. A distinct directional wind trend at specific hours was noted at Kagoshima under high pressure conditions. It was not determined whethere this was related to simple difference between heating of land and water surfaces or was caused by topographical irregularities. Kotsuki River Valley, Kagoshima Bay or the body of water that lies between Kagoshima and Sakurajima may have affected the wind flow. Perhaps a combination of these elements was at work. Clear conditions were short in duration during the middle of the Shurin, but increased toward the end of season.

An analysis of data for several years, perhaps a decade or more, will reveal the percentages of the various type of storms that affect Japan during the Shurin season. A regional picture of the relative importance of these storms can also be determined, as well as the frequency during specific periods during the season.

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